Slide Rules Are (Still)[1] … Music To My Ears!

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For centuries the slide rule was an invaluable calculating aid. But there was another side to Oughtred's invention. It proved highly adaptable and was used in many diverse ways – even for music!

What and why we collect?

After a first flush of enthusiasm, most ardent collectors choose a particular area of interest or a niche (e.g. "condition 0" [1] only) for their collection - sometimes reflecting their field of work or past profession. In my case, it was just what happened to appeal to me – 50, 60 or 100cm desk models, circular/disc rules and anything with a "whacky" scale or use.

"Whacky" scales

I am still discovering new and diverse ways slide rules were used but so far one of the most bizarre is a subject not intuitively associated with slide rules – the acoustic world of music.
Musical slide rules appealed to the organisers of the 2005 International Meeting of Slide Rule Collectors, held in Cambridge UK. Especially for the 12th International Meeting in Greifswald, Germany, the original paper has been revised and extended with new examples.

Acoustic rules

Using a slide rule for music may, at first, seem absurd and incongruous. But many aspects related to music are linked to mathematics and logarithms [2]. For example, Brook Taylor's (1685-1731) formula for calculating the form of movement in any vibrating string is still in use [3]. Indeed Taylor was first and foremost a gifted and respected English mathematician. He only devised the formulae to show how his most important work, *"Calculus of finite differences"* - published in 1715, could be used. So perhaps it is not altogether surprising that some enlightened inventors transposed music based concepts and complex formulas onto extraordinary rules.

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[1] Revised and extended from an idea first presented at the 11th Int. Meeting of Slide Rule Collectors and subsequently published in Vol. 15 of The Oughtred Society Journal.

Using selected acoustic rules out of my own collection and others I have heard about, I hope to show how music and slide rules can work in harmony. For each of the six featured rules, the relevant historical highlights, intended use and provenance are described. However, much of the associated acoustic and music theory falls outside the scope of this article and the knowledge of the author - I cannot read a note of music!

1. Faber-Castell: "Scaling Slide Rule for Organ Pipes – System Rensch"

Fig 1: Pipes in all sizes

Organs are built and maintained by specialists and include hundreds of wooden and metal pipes, flues and reeds. For example, the late 19th century organ in London's Albert Hall has a staggering 9,999 pipes. Since organs have existed since 3rd century B.C., it would seem reasonable to assume that after centuries of organ building, there should be little mystery left to organ pipe design. However, it is essential that any organ design takes account of the physical and acoustic properties of the building housing it. Essentially the frequency produced by an organ pipe is an inverse function of its length [4]. But there is an equally important relationship between the diameter and the length of an organ pipe – this is known as pipe scaling and it can have a dramatic affect on the tone quality, "colour" and volume. It should be easy to compensate for shortening an organ pipe by increasing its diameter. However, the resonance from two such "equivalent" organ pipes can sound disastrously different and for a long time shrouded the organ builders' work in mystery. Then, in 1833 a German, J.G. Töpfer (1791-1879), developed the "Normalmensur (NM)" standard or index that made it easier (but not easy) to predict the impact of pipe scaling. However, it was another German, Richard Rensch (1923-1997), who more than a century later appreciated the real potential for Töpfer's index. Rensch was a Master Organ Builder and after starting his own company, Richard Rensch Orgelbau Gmbh – Lauffen, he conceived a slide rule to solve the complex design problems associated with scaling organ pipes, flues and reeds. With the German specialist supplier to organ builders, Aug. Laukhuff GmbH - Weikersheim, who also held the initial copyright, they

commissioned A. W. Faber-Castell (F-C) – Stein, Germany to manufacture a special slide rule.
In 1969 F-C produced the first and only run of 500 large (395x90x8mm) white plastic *"Scaling Slide Rule For Organ Pipes – System Rensch"*. With 7 special scales (3 of which are inverted scales) and incorporating 2 nomograms, it ranks as one of the most technically challenging and impressive linear solid frame slide rules F-C ever produced [5]. On the reverse side of the frame there are two tables of theoretical pipe lengths with corresponding frequencies and two "how to use" diagrams. It also had a unique clip-on cursor extension specially designed for transposing some interim results onto graph paper.

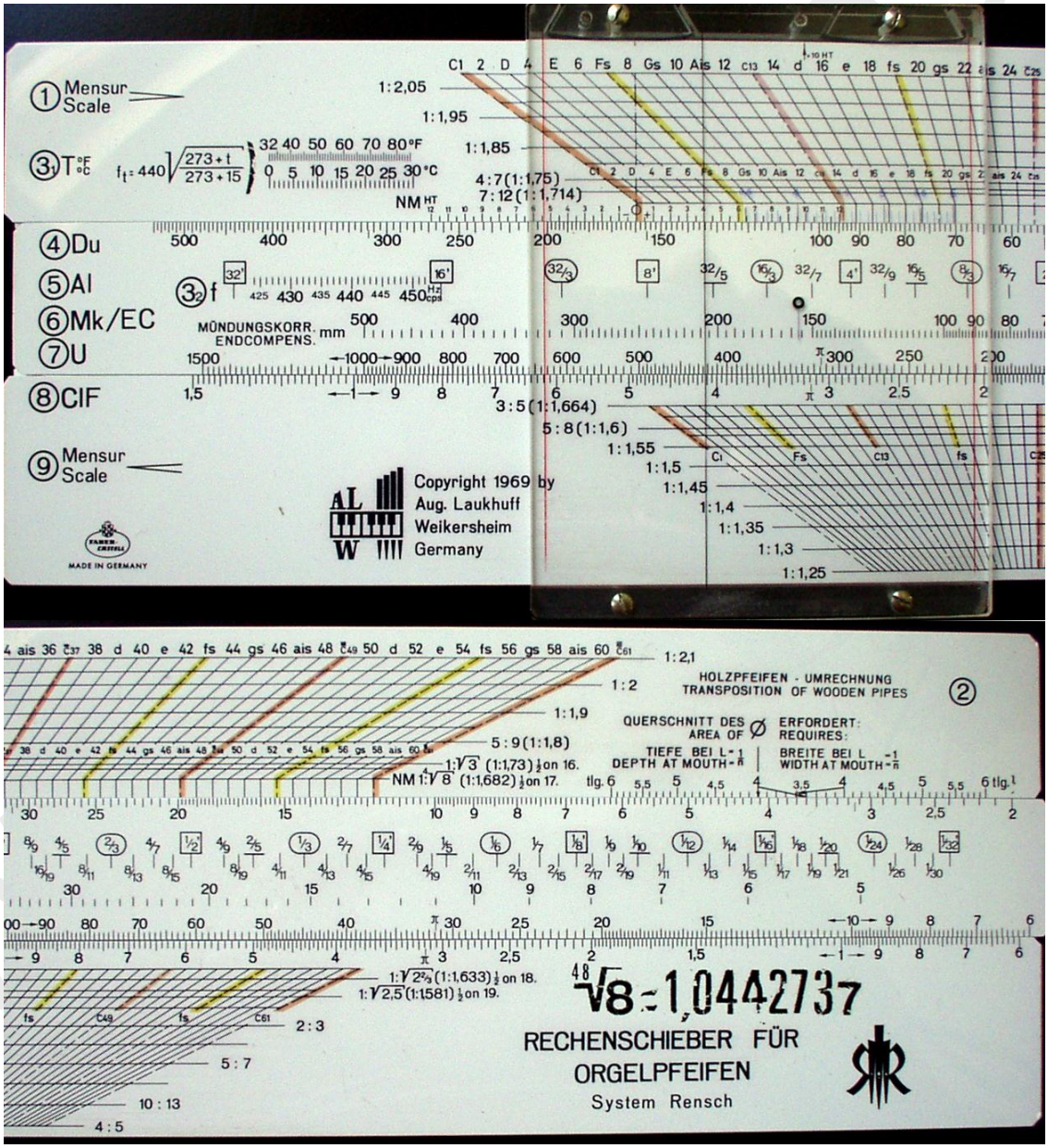

Fig 2: Extraordinary tooling for the F-C "System Rensch"

F-C never made a second batch run as it was considered "cost prohibitive" but regrettably all F-C pricing details have been lost. The System Rensch belongs to a category of specially commissioned F-C rules. Other examples are the ESSO, KODAK and BITZER slide rules. Being special commissions they never appeared in any F-C catalogue or in *"Slide Rules – A Journey Through Three Centuries"* [5, 6]. However, in 1986 (presumably all the F-C stock had been sold) they were still in demand. So a new manufacturer was found. An obvious choice would have been the German slide chart maker Ingenieurbüro für wirtschaftliches Arbeiten (IWA – the company name up to 1971) but there is no record of it in their archives [7]. The "second-generation" version was based on the F-C tooling with some minor modifications [8]. The collaboration with Aug. Laukhuff GmbH and accreditation was dropped. In its place Rensch's own company name, Orgelbau-Fachverlag – Lauffen, and © 1986 appear on the rule. However, to reduce manufacturing costs a much thinner (2mm) grade white bendable plastic was used, the cursor changed to a wrap-around sheet of thin transparent plastic and the clip-on extension became a simple set square. It was sold for 60 DEM. But the new version was less resistant to wear and tear and because the rule had a tendency to bend, it was trickier to use accurately. Production numbers for the post F-C period are unknown [9] but all sales were officially stopped in 2004. Perhaps not surprisingly, the replacement (also from Rensch) is a PC based program.
The F-C version, with its distinctive logo and "MADE IN GERMANY" (logo and text in black rather than the normal green) and 1969 copyright date, is superior and as only 500 were ever made, is notably rare and the one collector's should look out for.

2. Blundell Harling: "Note Tracker Slide Chart – P5731"

Although not strictly speaking a slide rule [10] this plastic slide chart has an impressive aesthetic design. UK musician and co-owner of C-Thru Music – Kettering, Peter Davies, conceived and designed the *"Note Tracker"*. First he invented a revolutionary way of mapping the symmetrical relationship between all 12 semitones of every octave in the harmonic table [11].

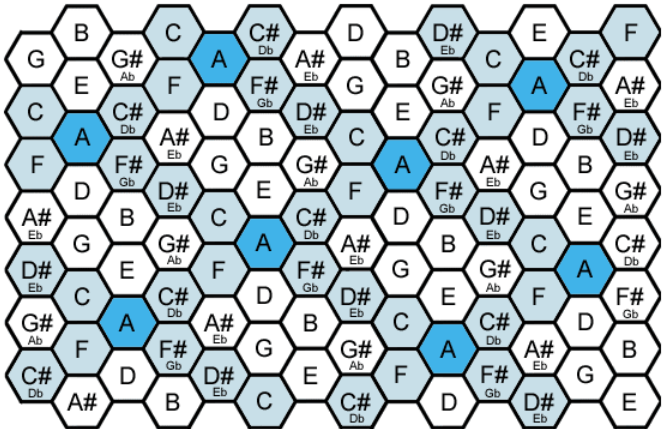

Fig 3: Patented Harmonic Table

In 1993 it received a UK patent (GB2245409). The American patent (US5415071) was granted two years later. For example, starting from the note "C", the next hexagon up to the left is a minor 3rd ("D#"), up to the right, a major 3rd ("E") and directly above, a perfect 5th ("G"). This unique harmonic map made it much easier to learn notes and chords.
In 1990 Peter Davies commissioned UK slide rule, slide chart and disc calculator manufacturer Blundell Harling [12] to make the "Note Tracker". The striking screen-printed slide chart (280x115x2mm – © 1987 Peter Davies) consists of a black background, overprinted in vivid green with a yellow inner sleeve depicting the patented symmetrical layout of the harmonic table. After selecting a root note such as "C", one side of the chart shows 18 major and minor intervals and 28 different chord types while the other side shows 22 corresponding scales or mode types (e.g. Enigmatic, Jazz, Blues, Melodic, etc). All types of musician, regardless of the instrument they played, could use the Note Tracker. Clearly it would have helped musicians primarily proficient at playing by ear. But equally a major burden for any musician exploring a new musical idea for a melody is transposing the notes into the corresponding scales and chords.

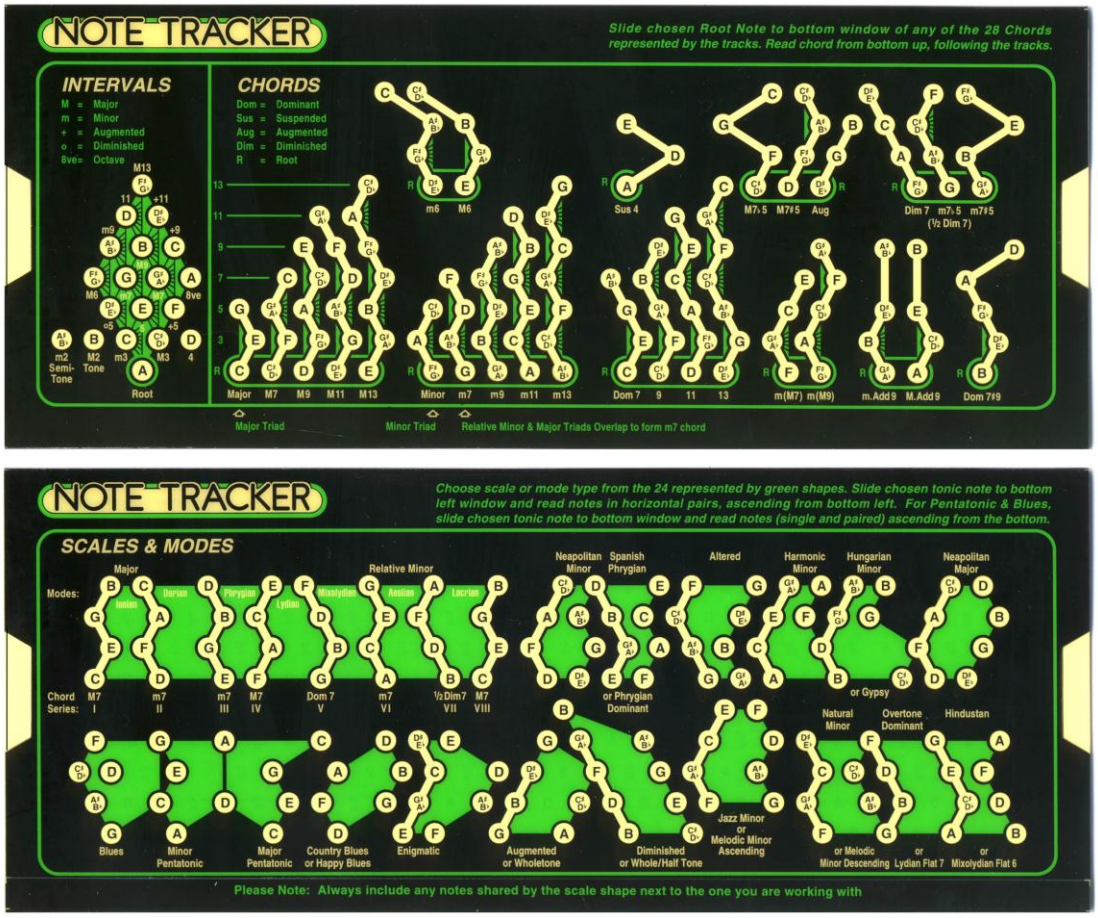

Fig 4: Note Tracker's aesthetic design – source H. van Herwijnen

As it was a not an internally developed product [13], Blundell Harling issued the slide chart with a "P-number": P5731. It was originally sold through various musical outlets but like many music related slide charts produced over the years, the Note Tracker was not a huge commercial success. Even at GBP 10.95 when first launched (the price later rose to GBP 25.00 to cover marketing costs) the size of the potential market was too small and the profit margin even smaller. Despite this, over four thousand were eventually sold – although the latter-day sales were only from C-Thru Music Ltd. Remarkably there is an epilogue to the Note Tracker. C-Thru Music Ltd has developed a revolutionary new musical keyboard called the "AXiS™" using the patented layout of the harmonic table.
Blundell Harling did make other music related slide charts but the most striking was the Note Tracker. It made simple what had previously been time-consuming and tricky even for a skilled musician. The Note Tracker would make a handsome accompaniment to any slide rule collection [14].

3. IWA: "Piano & Harpsichord Builders Slide Rule – TF 65/2"

Like organs, pianos and harpsichords are built by craftsmen and kept in tune by specialists. The basic principle of how a piano or harpsichord works needs no explanation. Less understood is the multitude of factors (many more intuitive than scientific) that builders and tuners have to wrestle with to make them sound their best – it is always a compromise. Until 1979 this was largely down to trial and error and years of experience. When hitting a single key on a piano or harpsichord the frequency of sound played is a reflection of the tension of the string being struck or plucked. Fortunately with Taylor's formula and the known length, diameter and (specific) weight of the string, it is possible to predict the tension needed for a particular frequency. However, even with the help of Taylor's formula it is not an exact science [3]. For example, the elasticity and tensioning properties of each string are not uniform. If the calculated tension means the string ends up too slack, the tone will be off. Whereas if the calculated tension means the string ends up over tensioned, there is a danger the piano or harpsichord housing cannot take the strain or it is too close to the string's breaking point and it snaps the first time it is struck. A further uncertainty comes from the need for wound (or covered) strings.
It is impossible to use an unwound or plain metal string of a practical length, diameter and weight for the

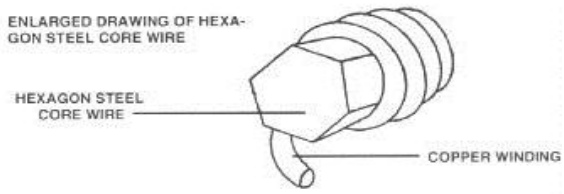

Fig 5: Typical bass string

bass section of a piano or harpsichord. So wound strings with a metal core and usually a copper outer winding are needed to get the required notes. But now the thickness and compactness of the outer winding also has an impact.
Commissioned by German music retailer Verlag Erwin Bochinsky – Frankfurt am Main, IWA – F. Riehle Gmbh & Co., copyrighted and manufactured in 1978 a pale grey and white plastic linear solid frame slide rule (380x40x3mm) with 12 scales - the *"TF65/2 Rechenstab für Saitenberechnung"* [15]. They based it on an earlier prototype by German master piano builder Klaus Fenner (1926-2005). Part of the design process included choosing the unit of measure for the scales. First there was the age-old problem of calibrating for metric or imperial weights and measures but also whether to use American, English or German wire sizes - metric and German wire sizes were adopted. Conversion factors for the alternatives are provided in the instruction manual [16]. The 3 scales on the front of the slide or tongue are for plain strings. The same scales but calibrated for wound strings, "Umsponnene Saiten", are on the back of the slide.

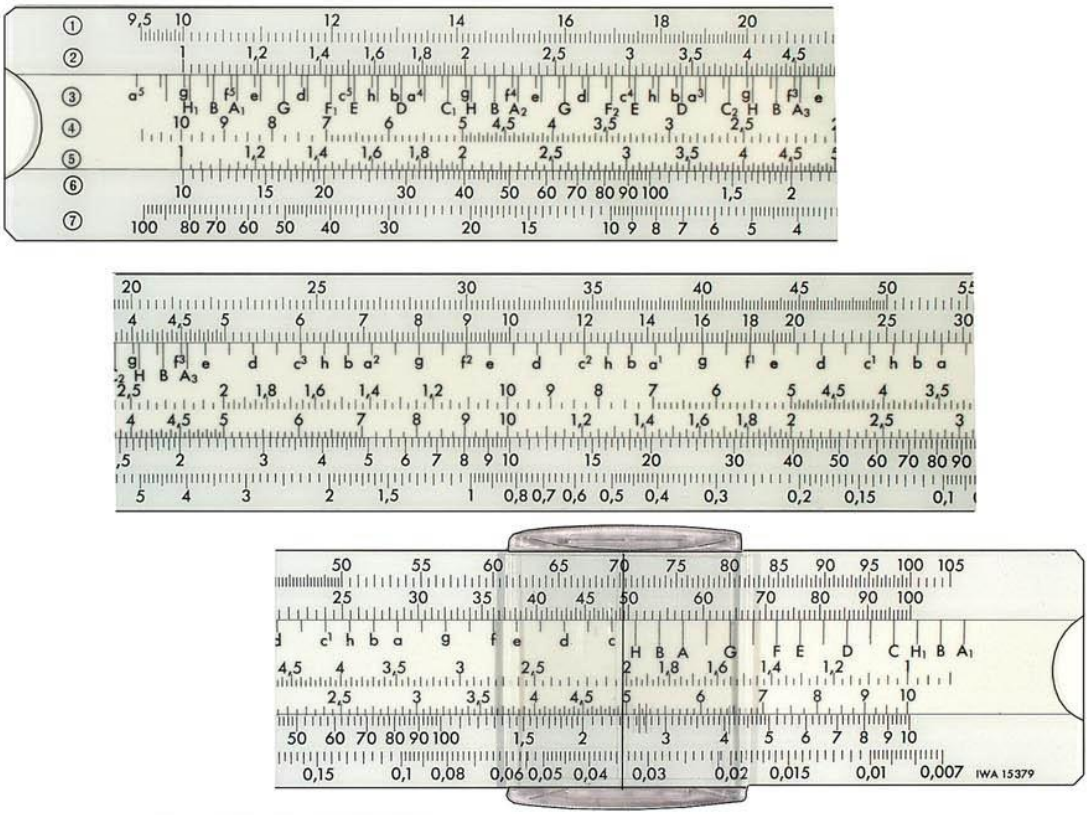

Fig 6: TF 65/2 Rechenstab für Saitenberechnung – source Herman van Herwijnen

Alternatively on the back of the frame is a table to recalibrate wound strings with a steel core and a copper winding as plain-wire strings. Also

since some harpsichords also use brass or bronze instead of steel as core wires, the cursor has two extra short hair lines for reading off the values for brass or bronze. These extra hairlines should be on the right of the main central cursor hairline – if they are not, the cursor is on upside down! Both the slide rule and the detailed instructions feature the trading name: "Verlag Das Musikinstrument". Any significance to the TF65/2 numbering is unknown but the slide rule also carries an IWA (post 1945) model number, 15379. IWA model numbers have an in-built classification. Starting with "15" shows that IWA classified the TF 65/2 slide rule as part of a group they called: "Sundries application purposes". The "379" suffix denotes the serial number within the group [17]. It has always been exclusively sold through Verlag Das Musikinstrument – Frankfurt am Main. The IWA archives show they received orders from Verlag Erwin Bochinsky for 1000 TF65/2's in 1978 and for another 1000 in 1979 and a final follow-on order of 500 in 1991 [7]. In 1995 the retail price was approximately 50 DEM. It is unclear if they are still being sold but perhaps it will strike a chord with some collectors.

4. Petit & Fritsen: "Carillon Builders Aid For Tone Ranges"

The Royal Bell-Founders of Aarle-Rixtel in the Netherlands, Petit & Fritsen b.v., have a rich history. Descended from a French family of travelling bell-founders, Alexius Petit (1720-1801) started the company in 1782. When the Petit family line had no more heirs, a nephew, Henricus Fritsen (1784-1875), took over the company. Two centuries later, Royal Petit & Fritsen is now the oldest Dutch family business and their foundry made bells can be found the world over – including Russia.

Fig 7: St.Paulus & Petrus Church, St.Petersburg

The business has passed continuously from father to son but it was descendant Hein Fritsen in the 1960's who came up with the idea of an aid to help build and set-up carillons - a musical instrument incorporating a series of bronze bells. They originated in the 15th century and have the

widest dynamic range of any mechanical musical instrument. They can be played manually (e.g. by a "Carilloneur" using a keyboard or by a group of campanologists ringing a peel) or by a pre-programmed mechanical/electronic movement (e.g. chimes of a clock or as a musical accompaniment).

The slide chart comprises of an outer disc (diameter 114x2mm) made of thin white flexible plastic with values printed predominately in black. A smaller inner disc, with more values and the company name and coat of arms in red and yellow, is riveted onto the outer disc. It is a slide chart rather than slide rule since it is impossible to perform calculations with any of the printed values. However, for a given note, e.g. "C1", the inner and outer discs can be lined up to show the weight, the diameter and note of each individual bell in the range for carillons of 1 to 46 bells [18]. It also has a special subsection to help set-up a "Westminster chime". A diagram of a bell mounting and a two-column table are depicted on the back of the disc. For any bell the size and the strength of the housing is crucial. Clearly the weight of the bell is a major factor but also the horizontal and vertical forces exerted when the bell is in full swing. For a given weight and bell tone, the table shows the minimum dimensions needed for the housing and bearings to be sure the bell tower does not collapse on the first peel.

Fig 8: Slide Chart for Carillons

The makers of the Petit & Fritsen disc are unknown. It has many similarities to other "special order" discs made by the Dutch slide rule manufacturer ALRO, but it misses the "anti-scratch" sealed finish ALRO put on all their discs [19]. Company records show that only one batch was ever commissioned but the size of the order and the unit price is

unknown. This is because Petit & Fritsen never considered it a commercial product. It was for use by their foundry staff or as a promotional gift to special clients. However, Dutch, French and English language versions all still exist. For the special collector this striking disc may ring a bell.

5. Lawrence Engineering Service: "9-K Music Transposer"

Transposing keys and constructing chords had enough marketing potential to not only attract slide chart manufactures but also conventional slide rule makers like the American company founded by George "Lee" Lawrence (1901-1976). The Lawrence Slide Rule Company probably started producing slide rules around 1935 but it better known from its 1938-1947 era as "Lawrence Engineering Service, Peru, Indiana" [20]. Like The Unique Instrument Co., in the UK, Lawrence produced inexpensive slide rules for the masses – as depicted in its marketing slogan; *"It's accurate and dependable"* [21]. The most common models, the "A" and the "B", had only a basic set of scales. Most model numbers also reflected the length of the rule. For example, the "8-A" is 8 inches long with just A, B, C and D scales. Correspondingly the "10-B" is 10 inches and has two extra scales – the CI and K. Much less well known are the Lawrence special purpose rules with a suffix in the range C to N - such as the "K" for the Music Transposer [22].
The "9-K" is interesting in several ways. First as its model number suggests, it is a natural wood coloured 9-inch linear closed frame rule (229x24x4mm). No other known Lawrence linear models are 9-inch and from its appearance, it is most likely cut down from a 10-inch closed frame blank. This argument is strengthened by the presence of tracks for a cursor although no cursor was provided nor is one needed to use the 9-K. It is copyrighted 1946 - a date common to most of the Lawrence special purpose rules.

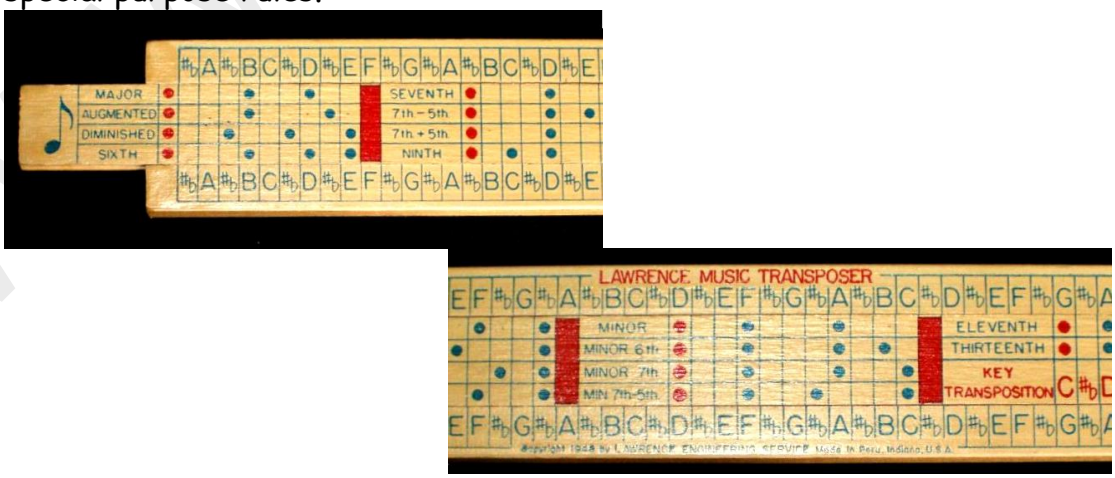

Fig 9: Special Purpose Music Transposer 9-K

The top and bottom scales are printed in blue on an off-white background and are identical: 5.3-cycles of a 12-step nonlinear scale. Note the special characters between most of the notes on the top and bottom scales: # indicates a musical sharp, and *b* indicates a musical flat. These allow the transpositions of keys that are either "sharped" or "flatted". The slide is mostly colour-coded in red and blue dots (on the same off-white background) for use with either the top or the bottom scale. After lining up the red dot for the desired chord against the chosen key, the blue dots give the corresponding semitones (e.g. a chord in Minor D = D + F + A). However, on the bottom right-hand end of the slide is an extra single cycle key transposition scale of 13 semitones - starting and finishing with C. By lining up a key on the slide with desired key on the bottom scale (e.g. transpose the key of C into G) all the notes of the transposed key (in blue) will be shown under their original semitones (in red). On the back of the rule is a set of instructions. The same instructions and a picture of the rule are printed on the accompanying paper pouch i.e. not the traditional Lawrence cardboard case.
It is unclear how many 9-K's were ever made or what the retail price might have been. But given the frequency the more common A and B models turn up, it seems reasonable to assume the 9-K is rare. From the information on the paper pouch, Lawrence Engineering was targeting musicians, composers, arrangers, teachers, students, etc. Perhaps it sets a "new tone" for Lawrence slide rules?

6. Oxford University Press: "A Musical Slide-Rule"

This British devised and made rule comes as part of a soft cover thin book (140x220mm and 28 pages). The book uses a black typeface on thin white paper except for the outer cover (also thin), that is a "dirty green". According to its author, Llewelyn Southworth Lloyd (1876-1956), the slide rule (in the book "slide-rule" is always hyphenated) was: *"Devised as an introduction to the study of the musical scale employed by composers and skilled artists."* The author, Principal Assistant to the (now defunct) Department of Science and Industrial Research, clearly felt it was important that musicians or science students realised that musical instruments can only roughly (and then only with frequent tuning) reproduce the vibrations depicted in a musical scale and appreciated the limitations of the human ear to hear tones.
The Oxford University Press published the volume in 1938. The original edition was never revised or reissued although extra copies of the slide rule could be purchased for one-shilling or 12 pre-decimal pennies

sterling. However, the author was clearly somewhat of a music aficionado and "tonal fanatic" as he authored other music related books published in 1937 and in 1940. The pocket to hold the accompanying slide rule is crude – the back cover being obviously cut "oversize" before being folded back and stuck down to form a flap or pouch. By comparison the "duplex" slide rule is much more robust. The scales (two of which are logarithmic) are printed in black on white paper that is glued onto thin strip of wood. It is a slide rule in the same way Oughtred originally used two Gunter's [10] i.e. the edges of the two rules are placed side by side and then one rule is slid along the other. Each duplex rule is 175x35x1.5mm. Sets of either lower or upper-case "x'" and "'y'" denoting which two scales go together.

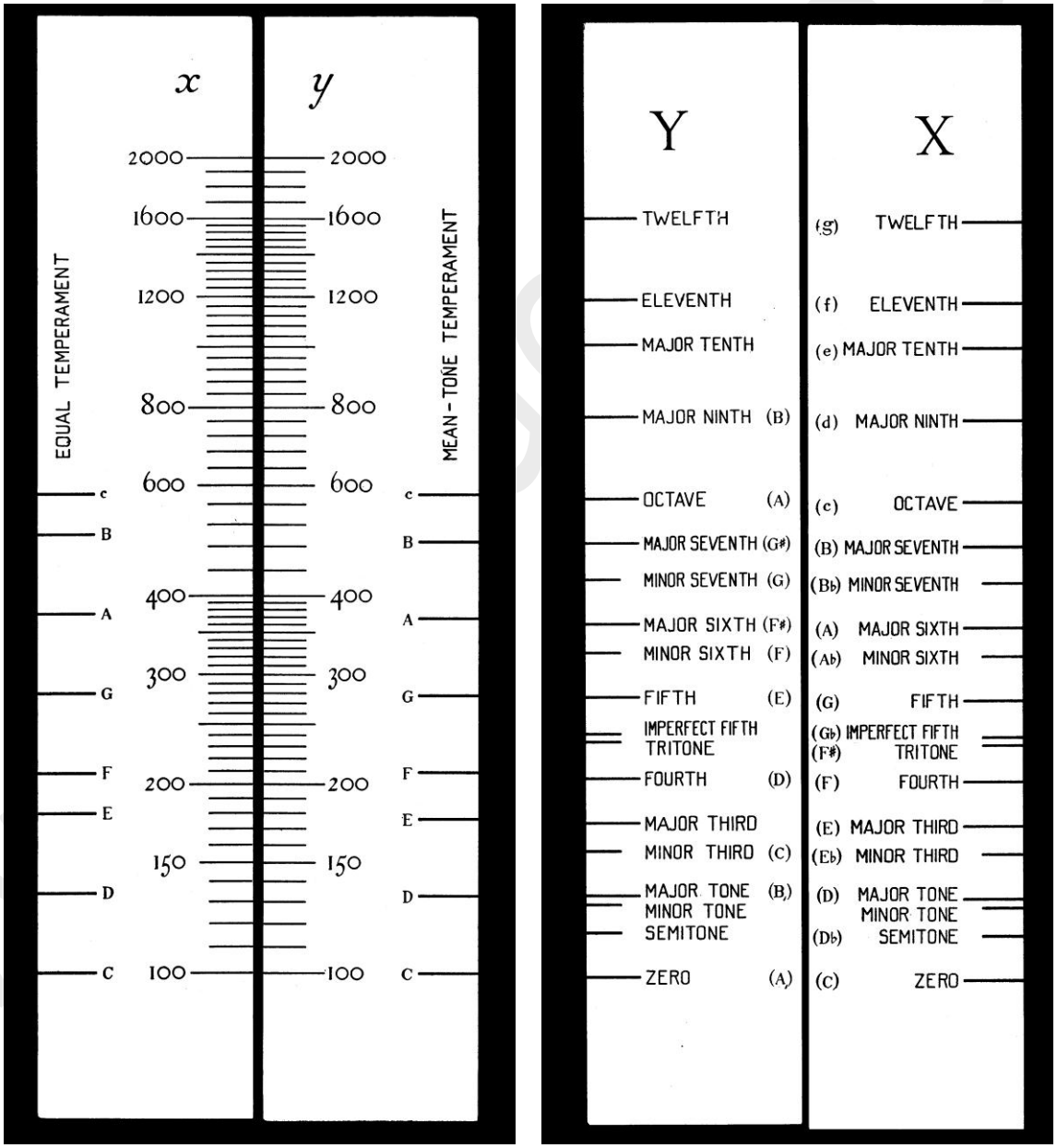

Fig. 10 - Both sides of the Musical Slide

Clearly the left-hand set of scales is logarithmic. Lloyd believed it was important musicians and students of music understood and appreciated the relative interval between each semitone in an octave. Interestingly he used mathematics, and in particular logarithms, to convey the concept before introducing the second set of non-logarithmic scales, depicting the full 12 semitones in an octave. In chapter 3 of the book Lloyd actually states that in learning about musical intervals, students have also learnt how to multiply and divide using a slide rule and states: *"He has learnt all he need ever know about logarithms."*
The harmonic overtones of this little book must make it compulsory reading for any collector.

7. New Discoveries

As part of my on-going research, I am continually discovering and acquiring other music-related rules. Surprisingly, examples span a time-frame from the 19th century up to 1990's and have diverse origins. To complete the "musical score" some are briefly listed:

- **"Musical Note Calculator" – late 19th Century**
  Probably French, Brice & Delineavant, circular "roulette wheel" wood, copper and glass calculator (Tesseract catalogue 2004),
- **"Musician's Slide Rule" – late 19th Century**
  English, linear closed frame boxwood slide rule for transposing notes between major and minor scales,

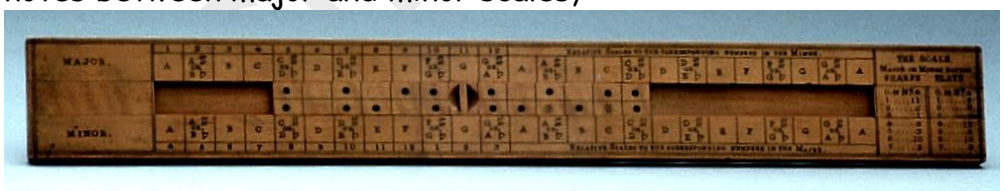

Fig. 11: By permission of "Museum of the History of Science", University of Oxford, inv. 51262

- **"IWA Music Slide Charts" – post 1945**
  German, music and harmony related slide charts produced for various companies in recent years [7]:
  IWA 15489: "> Harmonik <" for Dickmanns,
  IWA 15589: "Akkord-Schieber mit Transponierer", © 1989 Septec AG for Vogg Musik,
  IWA 15615/15452: "Pyramid® Lautensaieten-Rechner –System Ekkehard Sachs", © 1981 Ekkehard Sacks for Junger Gmbh,
  IWA 15657: "Musikkunde Schieber", © 1997 Horst Krüger for

Krüger IVB,
IWA 15749: "Saitenrechner", for Bernd Kürschner.

- **"Chord Selector" – around the 1960's/1970's**
  Russian, all metal (90x210mm) metal slide chart/aid for guitar players with a revolving wheel for selecting chords.

Fig. 12: All metal Russian Chord Selector

- **"Mechanical Musicalc" – 1993**
  Irish, slide chart developed by John Hesnan to help piano players quickly find the notes in any scale (Sunday Times, 25th July 1993),
- **"Blundell Harling Music Slide Charts" – pre 1998**
  English, music and harmony related slide charts and discs produced for various companies [23]:
  P 3679: "Chord Computer", © 1959 DKM Fuller for Dudley Fuller Associates,

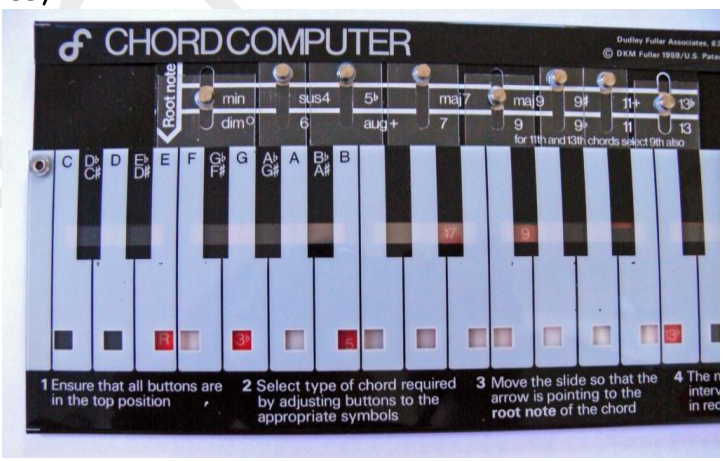

Fig. 13: Piano style Chord Computer

P 5012: Music Slide Rule for Standardgraph
P 5206: Music Slide Rule for Pale
P 5812: Music Data Bank for Invetorprise

- **"Barber Shop Harmony Calculator" – around 1976**
  English, Stanley Fearns (1920-1997), a circular disc [24] for a style of unaccompanied close harmony singing of typically four male voices. Almost certainly a limited edition (never marketed) for Stanley Fearns himself who sang in a choir and was a member of the "Tyneside Barber Shop Quartet" [25].

Closing Note (pun intended)

My aim, in a light-hearted way, was to show just how versatile Oughtred's original invention turned out and how the world of music unexpectedly provided the inspiration for some of the most fascinating and unusual examples of slide rules and slide charts. As I continue to collect, I am sure I will discover more "whacky" scales and yet more wonderfully diverse ways slide rules have been used.

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